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HEAD-LETTUCE PRODUCTION IN CALIFORNIA

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HEAD-LETTUCE PRODUCTION IN CALIFORNIA[1]

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THE ACREAGE devoted to lettuce in California has continued to increase for a number of years. Table 1 shows the California and total United States acreage for census years 1899 to 1934. During this period the California percentage of the total has increased from 1.8 in 1899 to 68.7 in 1934. The total rail and truck movement originating in California in

TABLE 1

LETTUCE ACREAGE IN CALIFORNIA AND THE UNITED STATES BY CENSUS YEARS

Census year	California	Otherstates	Total United States	Per cent California is of total
1899	46	2,586	2,632	1.8
1909	595	4,894	5,489	10.8
1919	6,121	15,423	21,544	28.4
1924	31,650	38,384	70,034	45.2
1929	60,564	53,207	113,771	53.2
1934	106,050	48,370	154,420	68.7

Sources of data:

1899-1929: United States Department of Commerce Bureau of the Census. Censuses of 1900, 1910, 1920, 1930, and the Agricultural Census of 1925.

1934: United States Department of Agriculture. Agricultural statistics 1936. p. 143. Washington, D. C. 1936.

1934 was 44,975 carlot equivalents or about 70 per cent of the total United States movement. In the same year this state moved as many cars of lettuce as the entire country did in any year before 1927 and over six times as much as the entire country did in 1918.[4]

PRODUCTION AREAS IN THE UNITED STATES

Production areas of some importance are scattered throughout the country. The New York variety is raised mainly in the irrigated regions of the West, the most extensive areas being in Arizona, California, Colorado, Idaho, and Washington. Although certain strains of New York are now grown in the East, they are not yet cultivated there extensively. The variety Big Boston is grown in the Middle West, East, and South, particularly in New York, North Carolina, South Carolina, and Florida.

[1] This circular is largely a revision of, and supersedes, Extension Circular 60, *The Head-Lettuce Industry of California*, by H. A. Jones and A. A. Tavernetti.

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[4] A detailed discussion of the economic aspects of the lettuce industry has been presented in: Wellman, H. R. Lettuce: series on California crops and prices. California Agr. Ext. Cir. 5:1–52. 1926. (Out of print.)

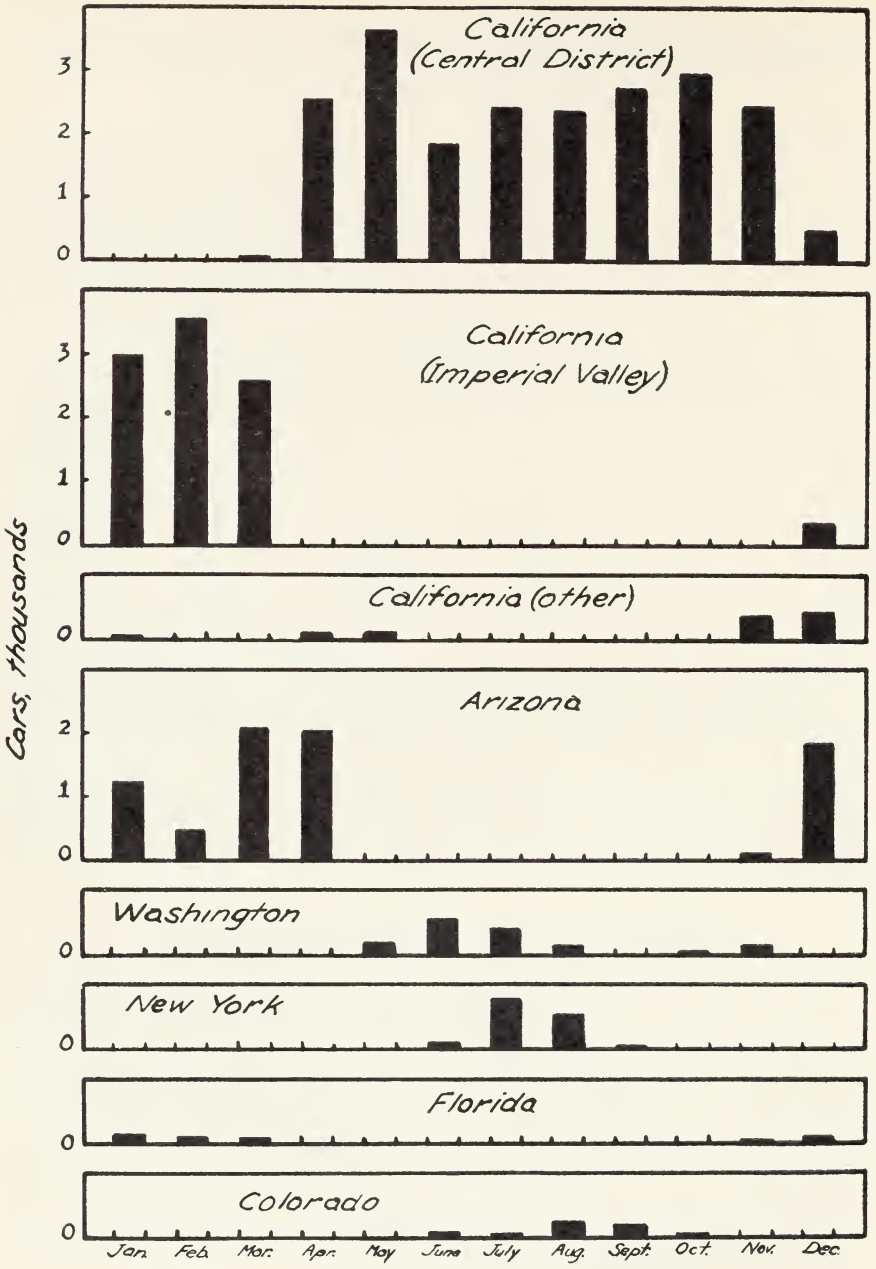

Fig. 1.—Monthly carlot shipments of lettuce and romaine from important lettuce-producing states; 1931–1935 averages. (From: United States Department of Agriculture Bureau of Agricultural Economics. Carlot shipments of fruits and vegetables by commodities, states, and months, annual issues.)

Figure 1 gives the carlot shipments of lettuce from important producing states for the five-year average 1931–1935. Though the shipping season of each locality varies slightly from year to year with seasonal conditions, the figure nevertheless gives the approximate time when lettuce may be expected to move from the different districts.

TABLE 2

LETTUCE ACREAGE IN CALIFORNIA BY COUNTIES, 1935

Counties	Season of harvest			Total
	Spring	Summer	Fall	
Alameda	150	50	100	300
Contra Costa	100	.....	100	200
Monterey	22,170	10,500	16,900	49,570
San Benito	660	100	600	1,360
San Luis Obispo	1,800	200	400	2,400
San Mateo	450	700	400	1,550
Santa Clara	100	.....	100	200
Santa Cruz	4,000	4,500	5,000	13,500
Solano	100	.....	100	200
Sacramento	220	.....	250	470
Yolo	600	.....	500	1,100
Fresno	.....	.....	50	50
Kern	150	.....	300	450
Merced	.....	.....	100	100
San Joaquin	300	.....	650	950
Stanislaus	.....	.....	500	500
Tulare	200	.....	500	700
Imperial	15,000*	.....	.....	15,000
Los Angeles	500	200	2,500	3,200
Orange	200	.....	100	300
Riverside	150	.....	50	200
San Diego	100	.....	100	200
Santa Barbara	2,000	2,400	2,000	6,400
San Bernardino	.....	.....	50	50
Ventura	150	.....	50	200
Totals	49,100	18,650	31,400	99,150

* The cutting season in Imperial is in late winter and very early spring.

Source of data:
California Coöperative Crop Reporting Service, Sacramento. California acreage of specified commercial vegetable crops by counties, 1931-1935. March, 1936. (Mimeo.)

PRODUCTION AREAS IN CALIFORNIA

The two main lettuce-producing areas of California are the Imperial Valley and the Salinas-Watsonville region, comprising the lower Salinas and Pajaro valleys. Several other districts, however, are located along the coast and in the interior. Their relative importance in 1935 is given in table 2, which gives the acreage by counties.

Shipping Seasons for California Lettuce.—Lettuce moves from California in quantity all the year around. For the five-year average of 1931–

1935 the lightest shipments were in June, with an average total of 1,859 cars. In the Imperial Valley lettuce is shipped mainly from December to March; in the Salinas Valley from April to November, with the spring peak in May and the fall peak in October.

Distribution of California Lettuce.—California lettuce is widely distributed throughout the United States and Canada during the entire year. Though most of it is shipped in solid carlots, some is moved in mixed cars. A considerable quantity, in addition, goes to nearby markets by truck.

CLIMATIC AND SOIL REQUIREMENTS

High-quality lettuce can be produced only where the temperature of the soil and air is moderately cool and uniform while the crop is maturing. This requirement must be remembered especially by those who are attempting to mature lettuce during the summer. Fluctuating high and low temperatures do not promote good growth. High temperatures favor the development of seed stems, a bitter taste, loose heads, and diseases. Early in its development lettuce will tolerate considerable frost; but, if severely frosted when mature or nearly mature, it is more subject to slime and therefore does not ship well. Usually, frosted lettuce needs close trimming and is therefore not attractive. The maturing plants grow very little during continued frosty weather, and though the heads may become solid, they remain small; their leaf tips are injured, and the trade considers them undesirable.

Lettuce must be adequately supplied with moisture throughout the growing season. Excessive water in the soil is, however, undesirable; and too much fluctuation in soil moisture may result in small, loose heads.

Although grown successfully on a wide variety of soil types ranging from clay loams to sandy loams and muck, lettuce attains its highest quality on fertile loam soils rich in organic matter. Where the fall crop is subject to high temperatures during its early development or matures during warm weather, the heavier types of soil should be used, for they hold more moisture and are cooler. The lighter, well-drained soils will serve for the crop that is planted and grown during the cool season. Because heavy-textured soils cannot be worked soon after a heavy rain, a definite planting schedule cannot easily be followed where rainfall is heavy during preparation and planting. All lettuce land should be well drained and properly leveled for irrigation.

MAINTAINING SOIL FERTILITY

The soil problems involved in lettuce growing are chiefly those of keeping a good soil highly productive. Where good lettuce land is almost unlimited, as in the Imperial Valley and north-central California, this problem is not so difficult. The central-coast district or Salinas-Watsonville area has ideal conditions for summer lettuce; but the area is limited. Here the only possible procedure is to plant the same soils with lettuce year after year.

Crop Rotation.—Though as many as five or six crops of good lettuce have been grown consecutively, usually no more than two are profitable without some rotation or without an intensive fertilization practice.

In the Imperial Valley, alfalfa is commonly used in the rotation. Lettuce is often planted directly on alfalfa sod, but more often cantaloupe or some similar cultivated crop is grown first. As a rule it is difficult to make a good lettuce seedbed and to control weeds immediately after alfalfa. Lettuce growers of the Imperial Valley follow no one system of rotation. Sometimes an early crop of lettuce and a late crop of cantaloupes are grown the same year. After being in cultivated crops for three or four years the land is usually resown with alfalfa. A deep-rooted legume crop followed by a series of shallow-rooted nonlegume crops makes a good rotation.

In the San Fernando Valley, lettuce is grown very commonly as an intercrop among deciduous-fruit and English walnut trees. It is planted in the fall when the trees are bare, so that shading is not extreme. Spring lettuce is also grown after fall crops of cauliflower, tomatoes, celery, or lettuce. Fall lettuce often follows spring potatoes. For the fall crop, seed is sown in August or September; for the spring, in November, December, or January. In Los Angeles County, where land is high-priced, it must be kept occupied with highly profitable crops.

In the Salinas–Watsonville district more than one crop is usually grown on the same soil in a year (fig. 2). This district is very fortunate because many crops can be profitably rotated with lettuce. The grower can work out a rotation with lettuce planted for harvesting at any time of the year.

Certain crops are harvested immature, require frequent irrigation, and leave the soil moist at harvest time; examples are lettuce, spinach, green peas, cauliflower, cabbage, broccoli, Brussels sprouts, endive, carrots, and celery. These should be rotated with crops that are harvested mature, that require less frequent irrigation and leave the soil dry—for example, dry beans, sugar beets, fall potatoes, onions, garlic, tomatoes, barley, wheat and vetch, garden-pea seed, and sweet-pea seed.

One can grow the following crops for spring harvest and still allow sufficient time to mature a crop of lettuce during the summer or fall: lettuce, garden peas, carrots, spinach, sugar beets, sweet-pea seed, onions, garlic, green peas, vetch seed, wheat, and barley. Crops grown for fall harvest include lettuce, green peas, sugar beets, tomatoes, potatoes, carrots, cauliflower, spinach, and celery.

Though there are many crop-rotation systems, the individual must determine the exact procedure to meet his needs. A few suggestions may

Fig. 2.—Fall crop of lettuce nearing maturity in the coastal region.

guide him. One plan is to alternate two crops of lettuce with one rotation crop, an arrangement whereby lettuce can be grown on two-thirds of the available acreage. Another plan now practiced successfully by a few lettuce growers is to carry out this rotation, but also to keep one-fourth of the land in alfalfa for three to four years. Alfalfa, however, does not fit well into the general lettuce-farming plan in the Salinas–Watsonville district and is profitable only to those who can market or use the hay. Lettuce growing in conjunction with dairying and alfalfa growing is an ideal combination.

The refuse of all crops, such as straw, stalks, or unharvested plants, adds organic matter and should therefore be returned to the soil. If large amounts of such material are turned under, nitrogenous fertilizers are usually needed to offset temporarily decreased fertility during decomposition.

With a large percentage of the California lettuce grown on leased land, crop rotation as a practice is the problem not only of the grower and shipper but also of the landowner. As rentals are based mainly on the ability of the soil to produce marketable lettuce, landowners who wish continuously to enjoy a satisfactory income obviously must use farming practices that will keep their soil highly productive. A lease should not dictate just what crops are to be produced; but it might well stipulate the number of crops of a single commodity to be grown in succession on the same soil, the disposition of crop by-products having fertilizer value, and other similar conditions of soil management.

Need for Organic Matter.—Active organic matter in the soil is essential to lettuce production. The term is applied to organic material which is decomposing and which can sustain bacterial life. The amount required varies with the soil type. Sandy and porous soils usually have a high rate of decomposition and become depleted much faster than the heavy soils. If sufficient active organic matter is maintained, additional fertilizing may not be required.

Organic matter in the soil may become inactive through constant wetting or through cultural practices used for a specific crop. A crop rotation that allows moderate drying and airing of the soil appears to stimulate decomposition of organic matter that has become inactive. Organic matter lightens the heavier soils and thus improves aeration and water penetration. It is usually supplied as manure or covercrops.

Manures.—The best fertilizer for lettuce on most soils is barnyard or other animal manure. If well pulverized the manures are usually spread and worked into the soil just before the beds are listed. Fresh and coarse manure should usually be composted before application, especially if lettuce is to be planted immediately. In composted manure more of the plant food elements are available, no coarse material present interferes with planting and cultivation, many noxious weed seeds have been destroyed, and no heating of the soil occurs. In composting, however, one should try to prevent leaching of the soluble salts and loss of ammonia. Fresh or unrotted manure, if used, should be plowed or disked under in time to decompose partially before the crop is planted, or should be applied lightly. In tests in the Imperial Valley, 10 tons of barnyard manure to the acre increased the total yield 54 per cent, caused the lettuce to mature two to four weeks earlier, and resulted in larger heads of better quality, than the adjoining unmanured plots. Manure on land in the Salinas Valley and other districts has also produced a striking response. Excessive applications, however, especially in warm weather, often result in loose heads.

Green Manure Crops.—Where one cannot obtain enough manure to supply the needed organic matter and plant food, green-manure crops alone or with commercial fertilizers, may be used. To grow green-manure crops is better than to leave the fields idle a part of the year. Such crops keep down the weeds, increase the total organic content, and help conserve the soluble mineral elements of the soil, especially in regions of heavy winter rainfall. They prevent erosion, help aerate the subsoil, and increase the favorable bacterial flora of the soil.

The covercrop or the green-manure crop (preferably a legume) should be adapted to local climatic conditions and should produce a good ton-

Fig. 3.—Brabham cowpeas in Imperial Valley. This crop yields about 24 tons of green tops to the acre. It is resistant to nematodes. (From Cir. 295.)

nage of vegetable matter. The choice of a crop will depend upon the planting time and the growing season. Usually a thorough disking is given before the green-manure crops are plowed under. If the soil is dry, irrigation after plowing will hasten decomposition. Decomposition must be fairly complete before the next crop is planted, otherwise injurious results may follow.

In the Salinas–Watsonville district green-manure crops such as mustard, vetch, or *Melilotus indica* are planted in early fall after the lettuce harvest. One must usually irrigate the land to germinate the seed; thereafter, the winter rains are sufficient to mature the crop. The following spring the growth is disked and plowed under. Garden peas are also used extensively for green manure, the vines being turned under as soon as the pods have been picked.

In the Imperial Valley, alfalfa is used rather often in the rotation. Green-manure crops are also employed to supply the necessary organic matter. In one test, Hubam clover appeared promising as a spring covercrop. When planted from January 1 to March 15 it can be plowed under

late in June. Brabham cowpeas (fig. 3) and certain varieties of soybeans have proved good summer green-manure crops: they produce a heavy growth and resist nematode attack. They are usually planted from May 15 to July 1 and require about 80 days to mature. Guar, another heavy-producing, summer-growing, nematode-resistant legume, planted in June, requires about 100 days to mature. The green-manure crop now used in Imperial Valley almost to the exclusion of all others is the common legume *Sesbania macrocarpa.* In trials at the Meloland Field Station, at El Centro, a red-stemmed species, *Sesbania cannabina,* offered equal if not greater promise. Sesbania is usually broadcast at the rate of 40 to 60 pounds of seed per acre, between May 15 and July 15, on land prepared flat for flood irrigation. The crop can be plowed under in 60 to 90 days.

The advantages of sesbania are its suitability to Imperial Valley conditions, its quick growth, its cheap production, its adaptability to flood irrigation, and its rapid decay. It outgrows most weeds. Most other summer crops, such as cowpeas, soybeans, and guar, grow more slowly and require cultivation to keep down the weeds. Average costs of planting sesbania in Imperial Valley in 1935 and 1936 are estimated at $7.50 per acre up to the time that it is plowed under. Sesbania is plowed under without being disked previously. Notched disk plows are commonly used. The growing of truck crops in beds and the "subbing" of the moisture to the plants tend to accumulate salts in the ridges. The flood irrigation required in growing the sesbania counteracts this tendency by leaching the salts to lower levels in the soil. Sesbania planted early in the season, plowed under in July or August, and then irrigated, is practically all decayed by the time lettuce is planted in October.

Sesbania has certain disadvantages. It is susceptible to nematodes, requires high temperatures and abundant water, and does not produce quite so much dry organic matter per acre as the other summer legumes mentioned above. It breeds alfalfa caterpillars and cucumber beetles. Lettuce, however, being grown during the cool season, suffers little from nematode attacks. The insects, particularly the alfalfa caterpillars, can be prevented from spreading to adjoining fields if the sesbania is plowed under at a medium stage of maturity, before it attains its full growth. The ease and cheapness of growing sesbania may overbalance its lower production of dry organic matter.

Commercial Fertilizers.—Some growers plant green-manure crops and in addition use commercial fertilizers to keep the soil highly productive. The three constituents supplied in a complete fertilizer are nitrogen, phosphorus, and potassium. Any one or all of these may be supplied

in organic or inorganic form. In the latter the elements are as a rule immediately available to the plant, whereas in the organic form the complex compounds must decompose into more simple forms before the plant can absorb them. This decomposition or change is accomplished by different types of soil bacteria. When the soil temperature is low, these bacteria function slowly or not at all; hence, during the cooler season at least, the fertilizers should be applied in the inorganic form.

Fig. 4.—One type of equipment used to apply fertilizer and list in one operation. After the fertilizer is dropped the lister covers it with soil. (Courtesy of the Cornell Tractor Co.)

Neither the kind nor the amount of fertilizer can be specified for the entire state or even for any large district. Each grower should make several tests on his own farm to determine which fertilizers to use and what amount to apply. Lack of nitrogen is usually what limits the growth of the lettuce plant. Nitrogen can be applied in the inorganic form as nitrate of soda, liquid ammonia, sulfate of ammonia, or calcium nitrate; or in the organic form in such materials as tankage, fish meal, cottonseed meal, and dried blood. A complete fertilizer is often broadcast or drilled in at the time the beds are made (fig. 4). At planting time some growers drill the fertilizer 1 or 2 inches below the seeds by using special attachments on the seeders. Inorganic nitrates may be applied immediately after the plants have been thinned and until about a month before harvest. Their application just after thinning and before the

next irrigation is usually to be recommended. In the Imperial Valley phosphate fertilizer applied before planting seems to result in earlier maturity, larger heads, and higher yields. Applications are usually either 200 pounds per acre of treble superphosphate analyzing 46 per cent phosphorus pentoxide (P_2O_5) or 500 pounds of ordinary superphosphate analyzing about 17 per cent phosphorus pentoxide. Heavier applications often give better results. The phosphate is broadcast on the ground before the beds are listed or on the plowed sesbania ground

Fig. 5.—A float used in leveling lettuce land in the Salinas Valley. (From Ext. Cir. 60.)

before it is disked and floated. The phosphate may be supplemented, after the lettuce is thinned, with a side dressing of nitrogen, such as nitrate of soda or liquid ammonia. With nitrate of soda the usual application is 200 to 300 pounds per acre; often there is a second application of 150 to 200 pounds. These applications are particularly useful in forcing growth when very cool weather or other conditions retard the development of the crop. One should usually not apply large amounts of nitrogen after the heads have begun to form. The use of inorganic nitrogenous fertilizers should be timed so as to produce a good growth before the heading period. Too much available nitrogen at heading time may result in large, soft heads. Many soils of the state respond more definitely to organic matter than to commercial fertilizers. Even the nitrates will not always produce the desired results.

PREPARATION OF LAND BEFORE PLANTING

Leveling.—In growing lettuce under irrigation the land must be smooth (fig. 5) and the beds of uniform height so that water can be applied without flooding certain areas and leaving others high and dry. Any leveling necessary should be done well before the planting season. If much soil must be moved, a test irrigation will settle it and will reveal the depressions and elevations. The necessary retouching can be done

after the soil has become sufficiently dry. After leveling, manure or a commercial fertilizer is often added where the top soil has been removed, so that a satisfactory crop will be produced.

Preparatory Tillage.—In general the soil should be plowed and then disked and harrowed to a fine, mellow condition before the seedbeds are made. To make good beds or do good seeding on a cloddy soil is difficult. When seeding is done during very hot weather, however, aeration is facilitated and better stands are obtained if the soil is left a little crumbly.

Fig. 6.—Preparing the soil in the Salinas Valley for the fall crop of lettuce after harvest of the spring crop. The land is first disked and then either plowed or deep-cultivated, as shown above, to loosen the soil before the beds are made. (From Ext. Cir. 60.)

When alfalfa land in the Imperial Valley is broken up for lettuce, it is usually plowed several months in advance and left rough until about a month before planting. It is next floated, replowed, again floated, and then given a quick irrigation. Sufficient time should be allowed after the first plowing to kill the Bermuda grass and alfalfa; and sufficient time after the second plowing to float, border, flood, dry out the soil, disk, float, and make seedbeds before the desired planting date. A common sequence of operations for land that has just grown a cultivated crop is plowing about 8 inches deep; double-disking and floating; and then replowing, disking, cross-disking, floating, and bedding. In some dis-

tricts more operations may be necessary, the method of handling depending a great deal on the soil type. Chisel cultivators, adobe harrows, and ring rollers are sometimes used in heavy soils.

Planting Practices.—Three general planting practices are employed in growing lettuce in California. The crop may be seeded on level ground,

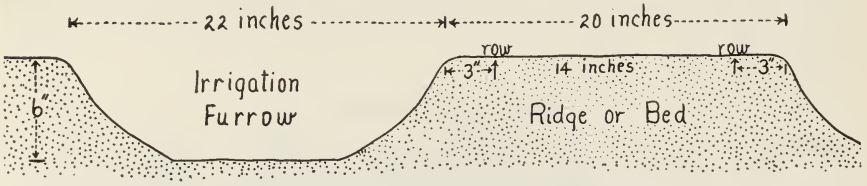

Fig. 7.—General type of bed and furrow used in the growing of lettuce in California. Dimensions vary according to local conditions. (From Cir. 295.)

on raised beds in dry soil, or on raised beds in moist soil. Planting without beds is used only in a limited way in certain coastal valleys where rain is the only moisture available. Under those conditions seeding is done in rows 20 to 24 inches apart after the first fall rains, and harvest is in the early spring.

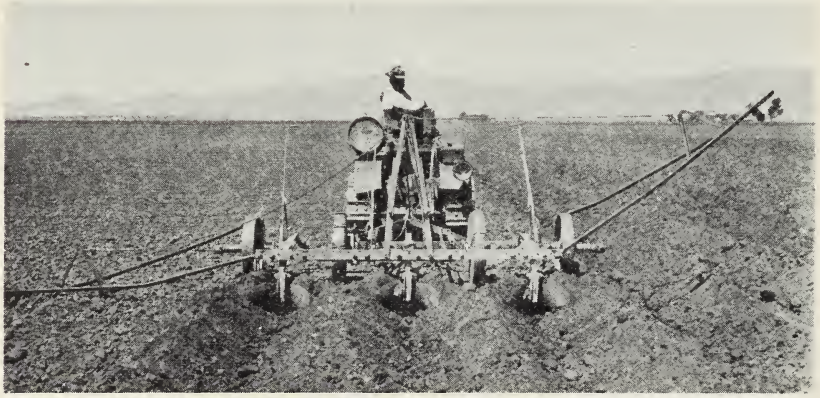

Fig. 8.—Making lettuce beds for a fall crop in the Salinas Valley with a triple lister. Double listers are also used when planting on a smaller scale. The beds are irrigated before seeding. (From Ext. Cir. 60.)

Almost all the lettuce in California is planted on raised beds, which facilitate irrigation, drainage, and aeration about the plants. The general custom is to grow two rows on a bed.

Making the Beds.—The width of bed, the distance between beds, and the depth of furrow vary in different regions according to climatic conditions and the type of soil. The beds are 18 to 20 inches or more in width, and the furrows 18 to 20 inches or more (figs. 6 and 7). Seldom are the beds less than 3 feet from center to center, and usually they are about 40

inches. They should be 4 to 8 inches high after smoothing. If the furrows are not sufficiently deep, there is danger of flooding. Inexperienced growers tend to make the furrows too shallow.

The rough beds are made with a lister pulled by a tractor (fig. 8). The rough beds may be shaped with a harrow or sled just before seeding or with the planter sled at the time of seeding. For very hard and cloddy soil, special equipment must often be devised to pulverize the beds so that they can be seeded.

SEED PRODUCTION

The production of lettuce seed is a highly specialized industry and not to be attempted by anyone not familiar with seed production. Figure 9 illustrates some of the complexities of the task of lettuce seed production.

Fig. 9.—Selecting desirable lettuce heads for seed. All undesirable heads are removed before the lettuce is allowed to go to seed. (Courtesy of the Ferry-Morse Seed Co.)

The plants selected for seed production are stripped of heads to allow the seedstalk to develop and the mature seed is later harvested by hand. Numerous reliable companies in California specialize in lettuce seed. Growers should purchase seed only from a dependable source.

VARIETIES AND STRAINS

The only variety of lettuce grown for commercial shipment in California is the New York, known to the trade as the "Iceberg" type. The true Iceberg variety, however, though resembling New York in habit of growth, has reddish leaves and is grown mostly for local consumption.

For some years the large number of strains of New York lettuce had been a problem to the grower, who was unable to determine which one to plant. Fortunately varieties have now become somewhat standardized, and many undesirables have been eliminated. Although much improvement is possible, new varieties are not likely to be introduced at the same rate in the future as in the past.

Fig. 10.—The New York No. 12 variety is not resistant to brown blight and is, therefore, planted only on land not infested with this disease.

The commercial New York strains can be grouped into two general classes, based on disease resistance: (1) those susceptible to mildew and brown blight; (2) those resistant to brown blight, including some partially resistant to mildew. All the resistant strains developed by Dr. I. C. Jagger of the United States Department of Agriculture are designated by the name Imperial; numbers following the name indicate resistance to brown blight, and letters partial resistance to mildew in addition to resistance to blight.

STRAINS SUSCEPTIBLE TO MILDEW AND BROWN BLIGHT

New York Regular.—For many years the strain generally known as New York Regular or New York Special was the only one planted. It has been improved from year to year and under favorable conditions produces a high percentage of uniform, good-quality heads. It is grown to

some extent in all districts where the soil is not infested with brown blight.

New York No. 12.—This selection (fig. 10) out of New York Regular was introduced by the Pieters-Wheeler Seed Company, Gilroy, California. It is an early, low-heading strain, somewhat lighter-colored than New York Regular and very uniform in appearance and in time of heading. The head is exposed, with comparatively few wrapper leaves. The variety has been exceedingly popular for several years. Not being resistant to brown blight, however, it has lately lost favor in the main lettuce-producing areas. It withstands warm weather satisfactorily and, where it can be grown, is an excellent variety.

New York No. 515.—This, one of the newer varieties, resulted from a cross between New York Regular and the true Iceberg and was developed by the Pieters-Wheeler Seed Company. It is partially resistant to tipburn. It does best for summer maturity in the Salinas–Watsonville section, and is also popular for the late spring crop in Arizona. In general appearance it resembles New York No. 12, being early and uniform, but is somewhat darker, with better and fuller wrapper leaves. Single-plant selections from the original have been increased; and these are larger, darker green, of better base structure than the present variety.

STRAINS RESISTANT TO BROWN BLIGHT

Imperial No. 13.—This strain, the largest of the Imperial types, was developed by Dr. I. C. Jagger and is used for harvest during the coldest part of the winter in the Imperial Valley. It requires a long growing period. Because of the limited period in which it can be harvested it must be planted between October 5 and 15.

Imperial No. 152.—This strain, also developed by Dr. Jagger, was released in January, 1934. It had been grown in a small way for several seasons preceding. Considerable commercial acreage was raised for shipment in December, 1933. The earliest of the Imperial strains, it is used for medium-late spring harvest, for early-fall harvest on the coast, and early-winter harvest in the Imperial Valley and Arizona. The plant is large, rather spreading, light grayish green, and set close to the ground. The leaf is thick, smooth, and rather soft. At first the heads are somewhat conical, with moderately twisted protecting leaves. At maturity they tend to be small, bald, flat, and very firm. The head leaves are long and overlap well. The base and interior of the head are well blanched. The variety is sure-heading and not inclined to bolt. It is immune to brown blight and resistant but not immune to mildew.

Imperial No. 615.—This strain was released by the United States De-

partment of Agriculture to seedsmen for the production of crops in 1934. It is a large winter type with spreading ground leaves and a tendency to coarseness. At first the young heads are well protected by twisted leaves and are low and somewhat conical. At maturity the heads tend to be bald and round or slightly flattened, with leaves well folded. The color is a medium-light grayish green. The stem is short; the base of the head

Fig. 11.—Imperial F, a brown-blight-resistant variety, also tolerant of downy mildew.

smooth and well blanched. The strain is well adapted for the production of early-spring lettuce along the coast and is used considerably for mid-winter harvesting in the Imperial Valley. At times it has produced excellent summer lettuce in the coast district, although it is generally believed not to be adapted to warm weather.

Imperial No. 847.—This variety, developed by Dr. Jagger, was released in the fall of 1935. It is of medium size and dark green. It heads well in warm weather and, next to "F," resists heat better than the other Imperial varieties. It is best suited to plantings in the coast district for maturity during the late summer and early fall.

Imperial F.—This strain (fig. 11), has produced consistently in the coast areas during the summer. It resists tipburn better than any other Imperial type. It is grown in late spring, summer, and early fall. Unfortunately it tends to fluffiness and looseness at certain seasons, particu-

larly in the early fall. It trims well and gives an excellent-looking pack in the crate.

Imperial D.—This resistant strain was released to seed growers in the fall of 1932. It grows slowly, being later than any strain now in use except Imperial No. 13. It is at least a week later than Imperial F. It makes a large, coarse plant, rather spreading in habit and forming large heads that are tall and pointed until near maturity, when they fill out and become round. The color is a dark, glistening green. The leaves are thick and crisp, with broad midribs. They are coarsely savoyed, with the margins very little waved. In warm weather the plant appears coarse and suckers badly. In cold weather it forms good heads, firm because of the crisp leaves. The coarse midribs make the head rather unattractive when opened; but the interior is well bleached, and the flavor excellent. This variety is particularly conspicuous because of its deep color and its crispness. It is an excellent early-spring and late-fall lettuce for coast districts. As it tipburns badly it is decidedly not a summer type. Imperial D is immune to brown blight and partially resistant to downy mildew.

TIME OF PLANTING

Lettuce requires 70 to 150 days to mature, according to soil and climatic conditions. The longest time is required for lettuce planted in early winter; the shortest time for plantings made for late summer or early fall harvest. Time of planting influences to an important degree the variety used.

In the Imperial Valley, seeding is done in the fall, and harvesting in the winter. The remainder of the year, the land is used for other crops.

In the interior valleys and south coastal districts an early-spring and late-fall crop are possible, the spring crop being planted during the winter months and the fall crop in late summer.

In the Salinas-Watsonville district, where cool, foggy conditions prevail during the summer, lettuce can be successfully matured at any time except from late December to the latter part of March. In this district three crops of lettuce can be matured on the same land in a single year; usually, however, only two are grown.

SOWING THE SEED

Various tools have been devised for sowing. From two to four rows may be sown in a single operation by implements like those in figures 12 and 13.

Lettuce seed, being very small, should be sown shallow, but sufficiently deep to be in contact with moisture. It will not germinate at high temperatures unless the soil is well aerated. In warm weather this aeration

is accomplished by leaving the seedbed slightly coarser than during the cool season. According to Borthwick and Robbins,[5] if lettuce seed is to be planted in a soil that has a temperature of 86° Fahrenheit or more during many hours of the day, good germination can be obtained by placing the seed in thin layers between moist burlap and then storing on ice

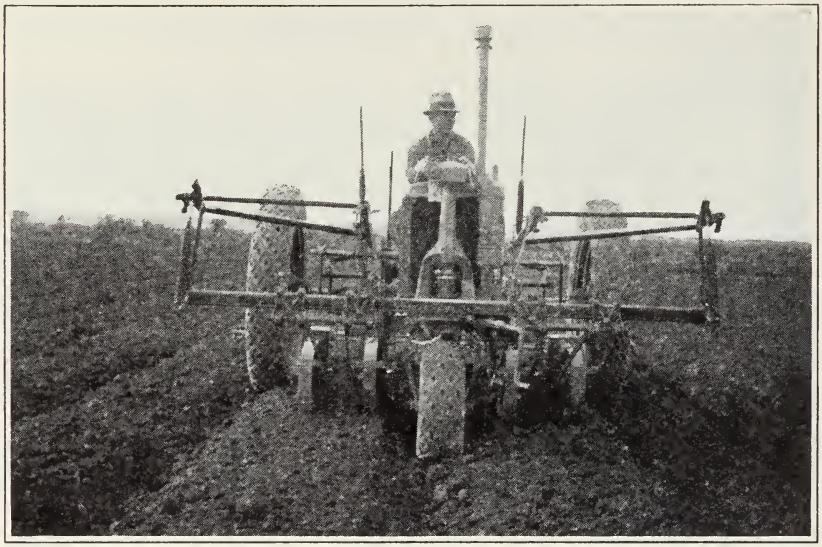

Fig. 12.—A seeder attached directly to the frame of the tractor. Sleds should be designed to smooth the top of the bed, to firm the soil so as to provide a good seedbed, and to carry the seed drills so that the seed is planted at a uniform depth and at a uniform distance from the center of the furrow.

4 to 6 days. Good aeration must be provided during this storage period. When the seed is then dried and planted in moist soil, a high percentage of germination is obtained.

Very thick seeding is objectionable. The labor cost of thinning a thick stand of plants is expensive, besides the waste of high-priced seed. From 1 to 1½ pounds to the acre will suffice if all the seed is viable and if the soil temperature and moisture conditions are good. Even under favorable conditions, however, a little more seed may give a better stand.

The distance between rows should be not less than 10 inches. Some growers space the rows 14 to 17 inches apart to permit the development of large heads. When the rows are too close together on top of the bed, cultivation is more difficult, various diseases are likely to appear, and the mature heads are usually smaller. On the other hand, the plants usually grow better if not too near the edge of the bed.

If a large acreage is being grown, successive sowings should be made

[5]Borthwick, H. A., and W. W. Robbins. Lettuce seed and its germination. Hilgardia 3(11):275–305. 1928.

at intervals of 10 to 14 days throughout the lettuce-planting season. In some projects planting is continuous throughout the planting period except when interrupted by adverse weather.

IRRIGATION AT PLANTING TIME

The irrigation system used at planting time varies with the locality, climate, and soil. In some regions the land is flood-irrigated, the beds are made, the seed is planted, and no further irrigation is given until the

Fig. 13.—Four-row lettuce planter in operation in the Salinas Valley. The beds were irrigated before seeding. (From Ext. Cir. 60.)

seedlings are through the ground. This system can be practiced where the soil dries out slowly. Since beds of moist soil settle more evenly after irrigation than beds of loose, dry soil, preliminary flooding is advantageous.

Where evaporation is very high it is customary, in addition to the preliminary flood irrigation, to irrigate immediately after planting or as soon as germination is desired.

Rough beds are sometimes made in land that has not received a preliminary flooding. The beds are wet by running water in the furrows (fig. 14). This irrigation moistens and settles the beds, which, when sufficiently dry, are smoothed and planted. This is the general practice in the Salinas-Watsonville district.

The fall crop of the interior valleys is usually planted in dry soil and then not irrigated until the grower desires to start the germination.

The following plan is sometimes used for the early plantings in the Imperial Valley: a preliminary flood irrigation is given; the beds are made and then irrigated. The tops of the beds, as soon as sufficiently dry, are harrowed with a special tool equipped with runners that slide in the furrows and prevent their being filled with clods. Seeding is started a

Fig. 14.—Irrigating lettuce beds before seeding, in the Imperial Valley. Water enters the furrows from the head ditch through small conduits. Usually only one is used for each furrow. The piece of shook beside the opening is used to regulate the flow. In most lettuce-producing districts another irrigation is given immediately after planting. (From Cir. 295.)

few hours later when the soil is dry enough for the planter to operate. The land is irrigated again, as soon after seeding as possible.

In furrow irrigation the water should "sub" until it finally moistens the entire bed. Irrigating immediately after planting is usually preferred in warm, dry weather. The water is often kept running in small streams down the furrows until the plants are up, in order to cool the soil and produce a high percentage of germination if the water is cooler than the soil. In cool weather such heavy irrigation immediately after planting is unnecessary. In heavy clay soils deep furrows are used with a small head of water. If the water comes near the top of the bed the soil will bake and crack when it dries, and the seedlings will not come through.

Regardless of location, however, the surface soil should be kept moist until after the seedlings are through the ground. In the hot interior valleys more care is needed than along the coast, where moist air and cool temperatures prevent rapid evaporation. The time of irrigation depends mainly upon the size of the plant and upon the climate and soil.

THINNING AND HOEING

Lettuce should be thinned before the plants begin to crowd. In warm weather this time may be three weeks after planting; in cool weather as long as eight weeks. The plants are blocked out 10 to 14 inches apart in the row with special short-handled hoes and at the same time are thinned by hand to one in a place (fig. 15). Those not true to type should be removed. The plants should have plenty of room in the row.

Fig. 15.—Thinning lettuce in the Salinas Valley. Plants are spaced about 12 inches apart. (From Ext. Cir. 60.)

Thinning is very important. Often when it is done under contract, part of the money is withheld until the job is finished satisfactorily. Beds and furrows are usually cultivated before thinning. Growers may stipulate that all weeds left by the cultivator shall be removed by the thinners, that the plants shall stand at a specified distance in the row, and that no doubles shall remain. Many growers, however, remove the weeds and doubles in a separate operation. When there is danger from insects, thinning should be delayed, if possible, until the pests have been destroyed.

IRRIGATING THE GROWING CROP

The details of irrigation vary considerably in different localities and at different seasons. Small plants need much less water than large ones. Less water is required when the weather is cool and humid than when it is hot, dry, and windy. The frequency of irrigation also depends on the water-holding capacity of the soil: as a rule, more irrigations are needed on light, sandy soils than on silt or clay-loam soils, retentive of moisture.

Water applied when the heads are maturing is apt to make them soft and loose. Heavy rains just before cutting time may make them open and spongy.

Experience will teach the grower just when to irrigate. As a rule the plants need water when the moisture in the surface foot of soil is nearly

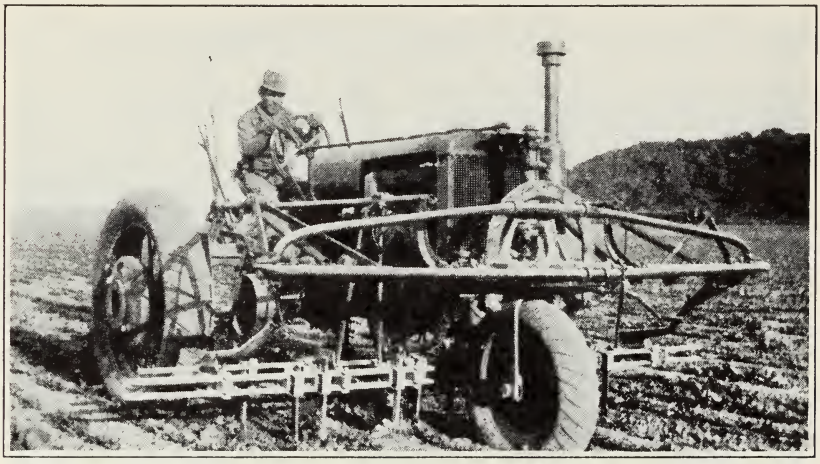

Fig. 16.—Cultivation before thinning.

Fig. 17.—Cultivator for replacing dirt against the plants after thinning.

depleted. When the moisture supply is plentiful the leaves are crisp and lighter green. In frosty weather some growers practice night irrigation to raise the temperature of the air around the lettuce.

Most growers use a series of wooden or metal conduits or flumes to

carry a small stream from the end ditch to the furrows between the beds. A conduit may be made of four laths or slightly wider strips, such as cantaloupe shook, 20 to 24 inches long, nailed together. It should be long enough to fit well in the ditch bank. Pieces of shook or lath can be placed in front of the conduits to regulate the flow. Galvanized or iron pipes cut to the same length as the wooden conduits are often used. Iron lasts longer. The usual sizes are 1½ to 1¾ inches in diameter.

Fig. 18.—Harvesting lettuce, showing the type of knife used and the method of cutting off the root just below the ground. (From Cir. 295.)

CULTIVATION

If weeds are abundant it may be necessary to cultivate before thinning (fig. 16). Often it is desirable to cultivate in order to open the furrow and in order to replace the soil around the young plants after thinning (fig. 17). Later cultivations may be necessary to destroy weeds that rob the soil of moisture and soil nutrients. Beyond this point cultivation is seldom necessary or even beneficial, though certain soil conditions require special consideration. The ordinary beet or bean cultivator gauged for several beds is satisfactory.

To insure close cultivation to the plant without injury, the number of beds cultivated in a single operation must correspond to the number seeded at one time.

YIELD

According to the Federal-State Market News and the California Coöperative Crop Reporting Service for the past few years, production of lettuce has averaged slightly less than one-half carload for each acre seeded. Amounts harvested per acre vary materially from year to year because of weather, insects, diseases, or poor market conditions. The average yield per acre for all sections of California in 1935 was 123 crates of approximately 75 pounds each.

Fig. 19.—Loading lettuce direct to trailers which go from field to packing shed.

HARVESTING

Growers sometimes harvest too soon, especially if the price is high. Lettuce should not be harvested until the heads are firm, which necessitates frequent cutting.

Harvesting should not be done when the field is muddy. Then, the plants being gorged with water, the leaves are crisp and brittle and break easily. If just slightly wilted they are injured less in handling and packing and consequently will carry better.

Lettuce should be cut just below the surface of the ground (fig. 18). Most of the trimming of the outer leaves should be done at the packing shed.

Harvesting is done by hand. A gang of men go down the rows, cutting the matured heads and tossing them into trucks or trailers (fig. 19), on which the lettuce is hauled to the packing shed.

Lettuce heads that are developing a seed stalk, or have burst, or show tipburn or slime should be discarded in the field.

In very warm weather or when freezes are expected, lettuce should be harvested as soon as it is hard. In cool weather mature lettuce can remain in the field for some time without bursting. As a rule, however, it should not be held long at any time if it is to be marketed in good condition and with a minimum of waste.

PACKING FOR SHIPMENT

At the packing shed the loose, diseased, and damaged leaves are trimmed off (fig. 20), and the small heads and loose heads culled out. When trimmed, the heads are tossed to the packing table, where they are placed in

Fig. 20.—Trimming lettuce. The butts and damaged or diseased leaves are trimmed off. The waste leaves are used for poultry, cattle, or hog feed. (From Cir. 295.)

the Standard California lettuce crate (fig. 21). In each crate are put 24, 30, 36, 42, 48, 60, 75, or 90 heads, according to their size. The growers and shippers, however, usually prefer heads that pack 4 or 5 dozen to the crate.

The lettuce crate is lined with two strips of heavy waterproofed paper, which cover the bottom, sides, and ends, and fold over the top. This lining protects the heads from dirt and drying, keeps them cool and fresh,

and guards them against mechanical injury. Three layers of heads are packed tight in the crate with stems up, generally with cracked ice between the layers (fig. 22). Usually not over 30 pounds of ice is used in

Fig. 21.—A modern packing shed. The lettuce is dumped from trailers onto an endless conveyor from which the heads are trimmed and placed on the packing table. (Courtesy of the E. H. Speigl Company.)

Fig. 22.—Cracked ice is placed between the layers of lettuce when packed. From 25 to 30 pounds of ice is used in each crate. This cools the lettuce and tends to insure its reaching the eastern markets in good condition. (From Cir. 295.)

each crate. The crates should be placed in the refrigerator car as soon as they are packed. From 4,500 to 7,500 pounds of crushed ice, the amount depending upon the weather, is placed in the car, usually on top of the crates (fig. 23) instead of in the bunkers. The ice on top of the load preserves the ice in the crates, and thus keeps the lettuce fresh for a long time.

FEDERAL STANDARDS FOR HEAD LETTUCE

The U. S. Standard grades for lettuce formulated by the Bureau of Agricultural Economics, United States Department of Agriculture, as of March 15, 1934, are as follows (numbers and letters in parentheses following grade terms indicate where such terms are defined under "Definitions of Terms") :

The tolerances for the various grades are placed on a container basis. However, for a tolerance of 10 per cent individual packages in any lot may not contain

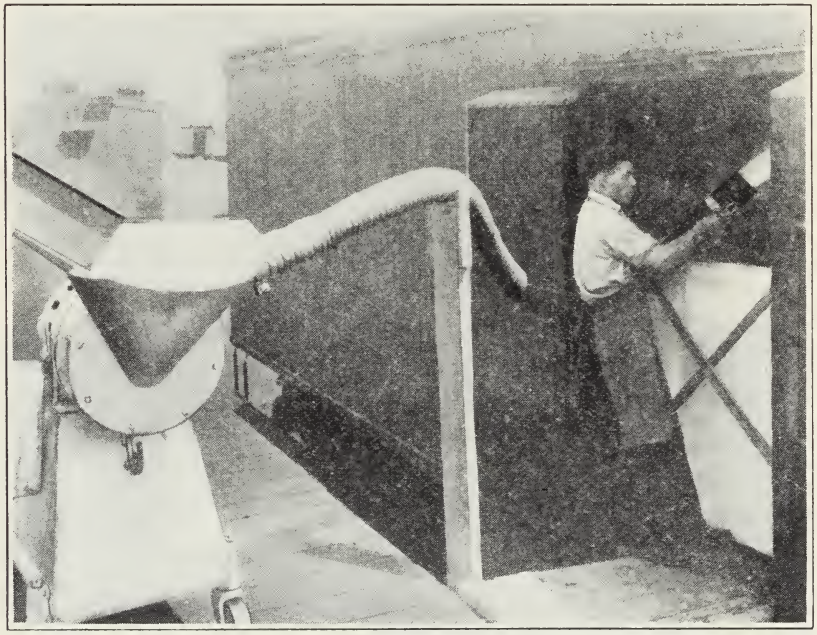

Fig. 23.—Top-icing refrigerator cars. Portable ice-blower in action, showing the use of rubber hose. (Courtesy of the Link-Belt Company.)

more than one and one-half times the tolerance specified, and for one of less than 10 per cent individual packages in any lot may not contain more than double the tolerance specified, provided that the entire lot based on sample inspection shall average within the tolerances specified.

GRADES

U. S. Fancy shall consist of heads of lettuce of similar varietal characteristics (1) which are fresh (2), firm (3), well formed (4) and well trimmed (5); which are not split, burst (6), or open, and which are free from decay, tipburn, russet, brown blight, doubles (7), and from damage (8) caused by seedstems (8a), broken midribs (8b), freezing (5 and 8c), dirt (8d), sunburn (5 and 8e), discoloration (5 and 8), disease, aphis (8f) or other insects, or mechanical or other means (8).

In order to allow for variations incident to proper grading and handling, not

more than 10 per cent, by count, of the heads in any container may be below the requirements of this grade, but not more than one-half of this tolerance, or 5 per cent, shall be allowed for decay affecting the compact portion of the head. Of this tolerance for decay, not more than two-fifths or 2 per cent, shall be allowed for slimy decay.

U. S. No. 1 shall consist of heads of lettuce of similar varietal characteristics (1) which are fresh (2); which are not split or burst (6), and which are free from decay, tipburn, russet, brown blight, doubles (7), and from damage caused by opening (8g), seedstems (8a), broken midribs (8b), freezing (5 and 8c), dirt (8d), sunburn (5 and 8e), discoloration (5 and 8), disease, aphis (8f) or other insects, or mechanical or other means (8). Each head shall be fairly well trimmed (9) unless specified as closely trimmed (10). Not less than 75 per cent of the heads of Iceberg type lettuce shall be firm (3), and the remainder shall be fairly firm (11). Heads of Big Boston type lettuce shall be fairly firm (11).

In order to allow for variations incident to proper grading and handling, not more than 10 per cent, by count, of the heads in any container may be below the requirements of this grade, but not more than one-half of this tolerance, or 5 per cent, shall be allowed for decay affecting the compact portion of the head; provided that, of this tolerance for decay, not more than two-fifths or 2 per cent shall be allowed for slimy decay. This tolerance shall not permit in any lot of U. S. No. 1 Iceberg type lettuce fewer than 90 per cent of heads which are firm or fairly firm and free from defects, on the basis of a ratio of three firm heads to one fairly firm head.

U. S. Commercial shall consist of heads of lettuce which meet all of the requirements of U. S. No. 1 grade except that they shall be free from serious damage by tipburn instead of free from tipburn.

In order to allow for variations incident to proper grading and handling, not more than 10 per cent, by count, of the heads in any container may be below the requirements of this grade, but not more than one-half of this tolerance, or 5 per cent, shall be allowed for decay affecting the compact portion of the head; provided that, of this tolerance for decay, not more than two-fifths or 2 per cent shall be allowed for slimy decay. This tolerance shall not permit in any lot of U. S. Commercial Iceberg type lettuce fewer than 90 per cent of heads which are firm or fairly firm and free from defects, on the basis of a ratio of three firm heads to one fairly firm head.

U. S. No. 2 shall consist of heads of lettuce of similar varietal characteristics (1) which are not split or burst (6), which are free from decay, from damage (8) caused by seedstems (8a), and from serious damage (12) caused by wilting, tipburn, freezing, disease, insects, or mechanical or other means.

In order to allow for variations incident to proper grading and handling, not more than 10 per cent, by count, of the heads in any container may be below the requirements of this grade.

DEFINITIONS OF TERMS

As used in these grades:

1. "Similar varietal characteristics" means that the heads in any container have the same characteristic leaf growth. For example, lettuce of the Iceberg and Big Boston types shall not be mixed.

2. "Fresh" means that the head is crisp, although the wrapper leaves and the outer one or two head leaves may be slightly wilted.

3. "Firm," as applied to heads of Iceberg type lettuce, means that the head is compact but may yield slightly to moderate pressure; as applied to heads of Big Boston type lettuce, means that the head is fairly compact.

4. "Well formed" means that the head is well shaped, and that midribs of the leaves are not abnormally prominent or protruding.

5. "Well trimmed" means that the butt is trimmed off close to the point of attachment of the outer leaves; that wrapper leaves are free from appreciable injury by any cause; that on heads of Iceberg type lettuce wrapper leaves do not exceed six in number, not more than one-half of which may be excessively large and coarse such as are characteristic of No. 6 strain; and, provided further, that the outermost leaves of the head show some shade of green color on a part of the leaves. "Wrapper leaves" means all leaves which do not fairly closely enfold the compact portion of the head. Heads shall not be considered well trimmed when the wrapper leaves are badly blistered or show yellow discoloration or more than slight brown margins. Heads with torn wrapper leaves shall not be considered well trimmed when such leaves appreciably injure the appearance of the head.

6. "Burst" means that the head is broken open.

7. "Doubles" means two heads on the same stem.

8. "Damage" means any injury which materially affects the appearance, edible or shipping quality of the lettuce except defects affecting wrapper leaves as restricted under definitions of "well trimmed," "fairly well trimmed," and "closely trimmed." The following shall be considered as damage:

(a) Seedstems which are apparent upon external examination of the head.

(b) Broken midribs, when more than two of the outer head leaves have the midribs broken in two due to abnormal growth conditions.

(c) Freezing, when the head leaves show a brown discoloration over more than half of the crown, or when more than three of the outer head leaves show appreciable injury by freezing.

(d) Dirt, when the head is smeared with mud, or when wrapper leaves are badly smeared with mud, or when the basal portion of the head is caked with mud or dry dirt.

(e) Sunburn, when the head leaves show a brown discoloration over more than half of the crown of the head.

(f) Aphis, when the head proper is infested, or when the wrapper leaves are badly infested.

(g) Opening, in hard or firm heads which have one-fourth or more of the head distinctly separated from the remainder, or any degree of opening in fairly firm heads.

9. "Fairly well trimmed" means that the butt is trimmed off close to the point of attachment of the outer leaves; that wrapper leaves are free from serious injury by any cause; that, on heads of Iceberg type lettuce, wrapper leaves do not exceed ten in number, not more than six of which may be excessively large and coarse such as are characteristic of No. 6 strain; and, provided further, that the outermost leaves of the head show some shade of green color on a part of the leaves. "Wrapper leaves" means all leaves which do not fairly closely enfold the compact portion of the head. Heads shall not be considered fairly well trimmed when the wrapper leaves show yellow or brown discoloration or brown margins to an extent that the appearance of the head is seriously injured. Any blistering except that causing yellow or brown discoloration which seriously affects the ap-

pearance of the wrapper leaves or any tearing of wrapper leaves shall not be considered as serious injury.

10. "Closely trimmed" means that the head meets all requirements of "fairly well trimmed" except that the wrapper leaves shall be not more than 3 in number, none of which may be excessively large and coarse.

11. "Fairly firm" means that although the head is not firm, it is not soft or spongy.

12. "Serious damage" means any injury which causes the loss of a material portion of the edible part of the head. The loss of crispness due to freezing shall not be considered serious damage. Heads affected with tipburn shall be considered as seriously damaged when any single spot is larger than one and one-half inches in length and/or three-fourths of an inch in width.

13. "Fairly uniform in size" means that not more than 10 per cent, by count, of the heads in any one container may be one standard size smaller than the standard size head for the count packed.

Example of Standard Size Head—The standard size head for a 4 dozen pack is that size which will pack tightly 4 × 4 heads of uniform size in a layer in the crate, assuming that the head has the average number of wrapper leaves found on all the heads in the crate.

STANDARD PACK

Heads of lettuce shall be fairly uniform in size (13), and tightly packed in uniform layers according to the approved and recognized methods, provided that a "bridge" may be used with sizes smaller than 5 dozen count.

In order to allow for variations incident to proper packing, not more than a total of 15 per cent of the containers in any lot may not meet the requirements of the Standard Pack, but no part of this tolerance shall be allowed for packs which are excessively loose in the layers.

CALIFORNIA STANDARDS FOR HEAD LETTUCE

All head lettuce offered for sale in California must comply with the provisions set forth in sections 814 and 828 in the Agricultural Code of 1935, as follows:

Head lettuce shall not be leafy without head formation and shall be free from slime, decay or rot affecting leaves within the head, internal insect injury, and free from seed stems which have so developed that they are apparent upon external examination; and free from serious damage caused by bursting, tipburn or freezing. Damage caused by bursting is not serious unless the head is burst open or is materially misshapen from this cause. Damage caused by freezing or tipburn is not serious unless it affects any portion of the head inside of the six outer head leaves.

Not more than ten per cent, by count, of the heads of lettuce in any one container or bulk lot may be below these requirements, but not to exceed one-half of this tolerance, shall be allowed for any one cause.

Head lettuce, when packed, shall not vary in size in any one container more than ten per cent of heads which would pack a size, larger or smaller, than the size marked, and they shall be tightly packed so that it is not possible without damaging or injuring the lettuce, to place additional heads in any of the layers of heads in the container.

All closed containers of packed lettuce shall bear upon them in plain sight and in plain letters on one outside end, the name of the person who first packed or authorized the packing of the lettuce, or the name under which such packer is engaged in busi-

ness, together with a sufficiently explicit address to permit ready location of such packer, and in figures not less than one-half inch in height the exact number of heads contained therein; provided that in the case of ten per cent of the crates in any lots the contents may vary not more than three heads from the count as marked.

All containers of head lettuce shall be standard containers numbers 45A, 45B, or 45C.

No.	Name	Dimensions		
		Depth inside in inches	Width inside in inches	Length inside in inches
45A	Standard lettuce crate	13¾	17½	21⅝
45B	Standard lettuce crate	13	17½	21⅝
45C	Half lettuce crate	9 or 9½	13	21⅝

Standard containers numbers 45A, 45B and 45C, when lidded, shall have a lid not over twenty-five inches in length. The inside length shown herein above for the standard containers numbers 45,[6] 45A, 45B, 45C and 46, shall be a minmum length, with maximum outside length of these containers of twenty-four and one-half inches; and the inside lengths of these containers shall be measured between the end slats, except that if flat end posts wider than one and one-half inches are used, the inside length shall be measured between the posts.

UTILIZATION OF CULL LETTUCE

In packing, large quantities of leaves and cull heads accumulate. The leaves analyze 94.7 per cent water, 1.27 per cent protein, 0.3 per cent fat, 2.9 per cent carbohydrates, 0.7 per cent fiber, and 0.9 per cent ash. Although this material is usually dumped as waste, it is a fairly good feed for range cattle during the season when there is a feed shortage on the range. Animals make fair gains on lettuce, the only harmful effect being bloat in a few cases. Mature cows on full feed eat from 100 to 125 pounds of lettuce per day. Cows fed lettuce, milk well and maintain fair condition, provided the ration is balanced by the addition of other feeds. The fat content of the milk remains about the same as when the herd is fed on silage and oat hay.

INSECT PESTS OF LETTUCE AND THEIR CONTROL[7]

Cutworms.—A serious pest of lettuce is the cutworm, which usually cuts off the young plants at the ground level. The best control has been obtained with the following poisoned bait:

Sodium fluosilicate	½ pound
Molasses	1 pint
Bran	25 pounds
Water	Sufficient to make a dry mash

[6] Containers 45 and 46 do not pertain to lettuce.

[7] This section was contributed by S. F. Bailey, Instructor in Entomology and Junior Entomologist in the Experiment Station.

Arsenic trioxide may be used at the rate of 1 pound as a substitute for the fluosilicate. The molasses may be omitted without greatly detracting from the effectiveness of the bait. Rice meal, shorts, or alfalfa meal may be substituted for the bran.

The poison and bran should be mixed thoroughly when dry. Dilute the molasses with a little water, and add to the dry mixture while stirring. Continue to add water until a crumbly mash consistency is obtained. This poison bait should not be mixed with the hands. Unless both water and poison are uniformly distributed in the bait mixture, unsatisfactory results will be obtained when the bait is scattered in the field. *If poison bait is used after the plants begin to head up, extreme care should be taken not to allow the mash to fall into the heads.*

The freshly prepared mash should be spread on top of the beds or near the plants in the early evening, for cutworms feed chiefly at night. The application recommended is 10 to 15 pounds of the bait per acre. If the cutworms are very abundant, two or three applications at 2-day intervals may be necessary.

Calcium arsenate may be used as either a dust or a spray, *but only when the plants are young because of the danger of poisonous residue.* This material is necessary for the control of certain species such as the yellow-striped armyworm.

Corn Earworm.—In the coastal areas the corn earworm (*Chloridea obsoleta*) occasionally injures lettuce. The adult, a night-flying moth, emerges from the overwintering pupa in the soil in late spring. It deposits eggs on various host plants, particularly corn and tomatoes. The larva matures in about 15 to 20 days and enters the soil to pupate. About 10 days later the adult moth emerges. There are three or more broods a year; this results in a gradual build-up of the population, which sometimes infests lettuce in the fall. Lettuce itself is one of the least attractive host plants, being rarely attacked unless adjacent to corn or tomatoes. For this reason it should not be planted next to corn fields or after corn or tomatoes known to have been infested. The use of insecticides is hardly necessary and is usually questionable after the plants attain size, because of the poisonous residue. After harvest, the infested fields should be thoroughly plowed to destroy all lettuce plants and to prevent the remaining larvae from developing.

Alfalfa Semi-Looper.—Along the coast, serious damage is often done by the alfalfa semi-looper (*Autographa californica*). The adult moth lays the eggs directly on the plant. In about 10 days these hatch into green larvae, which crawl in a looping fashion. From 4 to 6 weeks later the larvae reach full growth—a length of about ¾ inch. They then leave

the plants and pass through a resting or pupal stage in the soil. Sometimes they appear in small numbers before thinning and later concentrate on and severely damage the remaining plants. The most serious injury is destruction of the terminal bud, which prevents normal growth.

The larvae usually mature and leave the lettuce before the plants begin to head up, and the injury is thereby greatly lessened. Mature plants that have been injured are susceptible, however, to slime rot because of the injured tissue.

Fig. 24.—Power duster for controlling leaf-eating insects. As much as 60 acres can be covered in one day. (Courtesy of the Fry Seed Company.)

This pest can be controlled by spraying with 3 pounds of lead arsenate to 100 gallons of water or by dusting with a 50 per cent mixture of lead arsenate, calcium arsenate, or zinc arsenite, about 15 to 20 pounds per acre. Barium fluosilicate, 8–10 pounds to 25 pounds of a carrier such as talc, is also recommended. Sodium fluosilicate is not suggested because it may burn the plants, in the presence of moisture. *These materials must not be applied after the lettuce is more than one-third developed* (fig. 24) *because of the hazard of leaving poisonous residue.*

Caterpillars.—Occasionally other larvae besides the semi-looper and cutworms injure lettuce planted near uncultivated fields or poorly tended or abandoned crops. The caterpillars hatch in these areas and when mature, or nearly so, migrate to seek more food or a place to pupate. At such times, usually late in the summer or early fall, limited areas of lettuce are attacked. If abundant and migrating in a definite direction, the caterpillars can be trapped in a trench dug with the steep side toward the lettuce.

Frequently in the fall the caterpillars of the acraea moth (*Estigmene acraea*) appear, eating everything in their path. These woolly-bears or salt-marsh caterpillars may injure lettuce, especially the young plants.

In the immature stage the caterpillars are hairy and gray. Later they turn darker, with yellow broken lines and brownish red hairs. At maturity they measure about 2 inches in length. They pass the winter in this stage. After pupation, which occurs in spring, the moths appear. These have a wing expanse of 2 to 2½ inches. The females are white with the exception of the abdomen and the hind wings, which are orange. Wings and abdomen are spotted with black. The acraea moth can be controlled successfully with arsenical or fluosilicate dusts. *These dusts must not be applied after the lettuce is more than one-third developed because of the hazard of leaving poisonous residue.*

Grasshoppers and Crickets.—Grasshoppers are known to damage young, fall-planted lettuce severely. Crickets occasionally also prove injurious in the fall but frequently injure the outer leaves only. Such damage may be expected where lettuce fields adjoin alfalfa, pasture, or grain land; these fields should, if possible, be thoroughly disked or harrowed during the winter. Alfalfa land that is being broken up for lettuce should be disked and harrowed before plowing to destroy grasshopper eggs and various stages of insect pests found in the top soil. As a regular practice, grass and weeds should be burned, and the ground worked along the roads and ditch banks near the lettuce fields, for the grasshoppers lay their eggs in the undisturbed surface soil of these areas.

As soon as grasshoppers or crickets appear, irrigate heavily to moisten the ground and close up any cracks. The most satisfactory control is the poison bait recommended for cutworms. Better results are obtained, however, by adding to the poison bait about a dozen lemons or oranges, finely cut or ground, and the amount of molasses should be increased to 2 quarts. This mixture, freshly prepared as directed above, should be broadcast in the early morning for grasshoppers or in the evening for crickets. The same precautions should be used with this poison bait as explained in connection with control of cutworms.

Aphids.—Two types of aphids are prevalent on lettuce; one infests the leaves, and the other the roots. The two appear somewhat similar. The leaf aphid, if abundant, weakens and stunts young plants by sucking out the juice. A sticky secretion called honeydew, deposited on the leaves, renders the mature plants unfit for market.

The root aphid is found clinging in cottonlike masses to or near the roots. If the infestation increases, the plants become yellowish and unhealthy and may wilt during the middle of the day. Root aphids are more

abundant in heavy soils that tend to crack and crumble than in the lighter, more sandy soils that remain compact.

As the colonies increase, winged forms are produced and spread the infestation. The females give birth to living young in large numbers. Thus, if unchecked, the infestation builds up rapidly.

Natural enemies may at times control the leaf-inhabiting type of aphid. The larvae of the common ladybird beetles and the syrphid flies feed upon it. Some aphids are parasitized by insects and thus destroyed. Under warm, humid conditions certain fungi likewise tend to check them. As a rule, serious outbreaks occur during long periods of cloudy, damp, or foggy weather that render the natural enemies inactive.

Leaf aphids can be controlled by spraying with nicotine sulfate, 1 pint to 100–150 gallons of water, or by dusting with a 2–4 per cent nicotine dust. To obtain the best results applications should be made only when the temperature is 70° Fahrenheit or above. In both spraying and dusting one must actually contact the insect. This procedure is often difficult, because most of the pests occur on the undersides of the leaves.

Root aphids are difficult to control because it is almost impossible to contact them with any material at a reasonable cost. Damage can be held to a minimum by frequent irrigation, which keeps the soil expanded and close to the roots. The plants are also kept growing by the abundance of moisture and are thus enabled to withstand considerable injury. Immediately after harvest the field should be plowed or cultivated to destroy all plants that might serve as insect hosts.

Wireworms.—Wireworms or the larvae of click beetles injure lettuce by cutting off or burrowing into the taproot. They are yellowish brown and segmented and are ½ to 2 inches long. In spring and summer they feed close to the surface on various weeds and cultivated plants. If they find sufficient food in the spring, they may go deep into the soil in late summer and fall and not injure fall lettuce. They pass the winter in the soil and spend from one to three years in the larval stage.

Control is extremely difficult and seed treatment or poison baits are useless. Wireworms have been controlled by attracting them to a trap crop and then destroying them with poisonous gas. The field should be clean-cultivated, and the soil well pulverized. The trap crop such as cull peas and beans, is drilled into the soil about 4 inches deep; and the wireworms soon congregate about it. In 5 to 8 days, granular calcium cyanide is drilled at about the same depth as the trap-crop seed, at the rate of 75 to 100 pounds per acre or about 6 pounds to 1,000 feet of row. The moisture in the soil reacts with the calcium cyanide to form hydrocyanic acid gas, which destroys the wireworms.

The Coast Lined June Beetle.—The Coast lined June beetle (*Polyphylla crinita*) was found infesting lettuce fields on the Pacific Coast for the first time in the fall of 1936. The larvae feed 5 to 6 inches below the surface of the soil. The taproot is cut off, and the lower portion of the root is completely eaten, so that the plants wilt and die. The stands are thereby materially reduced.

The adult beetle is 1 to 1¼ inches long, very robust, and brownish gray, with a series of parallel longitudinal white lines on the dorsum. The larvae or "grubs" are large, white with a brown head, and 1¼ to 2 inches long. They usually occur in sandy soil. The adults appear in the spring and summer months. Indications are that they have a three-year cycle.

There are no practical means of control in lettuce fields.

The False Chinch Bug.—This small insect (*Nysius ericae*) occurs in the Salinas Valley periodically. To be of any economic importance they must appear in countless numbers. They usually injure young lettuce plants before or after thinning, to such an extent that fields often require replanting.

Most of the contact insecticides are of little avail. Practically 100 per cent control of the larvae has been obtained by using a spray containing ¾ per cent pyrethrum and ½ per cent light summer oil, emulsified in water. This treatment has little effect on the adults.

Nematodes.—On sandy and light soils the garden nematode may cause considerable loss. The pest is easily recognized by the nodule growth on the roots. When attacked early in growth the lettuce fails to reach maturity, remaining dwarfed and unthrifty. Damage usually occurs first in small areas that continue to increase in size from year to year. Other than crop rotation, no control is economical.

INJURY BY BIRDS

In some sections of the state English sparrows and horned larks often detroy many acres of young lettuce. Probably the best control is to place a large number of scarecrows throughout the field in the form of bright pieces of cloth or paper fastened to laths or sticks. The use of a shotgun for a day or two will help to scare the birds away. Scattering chicken feathers has proved successful in some districts.

DISEASES OF LETTUCE AND THEIR CONTROL[8]

Lettuce is no exception to the rule that with intensive propagation of one crop, one or several serious diseases gradually become epidemic. In California four diseases have become serious within the past twenty

[8] This section was prepared by G. E. Scott, Extension Specialist in Plant Pathology; and by members of the Division of Plant Pathology.

years. Brown blight (cause unknown) has been present in Imperial Valley since 1912. Downy mildew (*Bremia lactucae*) occurs in Imperial Valley but is usually more prevalent in the coastal sections. Tipburn (actual cause unknown) occurs annually in most of the important lettuce districts and is thought to be induced by certain unfavorable climatic conditions. Slime (caused by *Botrytis* spp. and certain bacteria) usually attacks plants previously injured by tipburn. Besides these four diseases, minor ones occur annually but do not usually cause heavy losses. Spotted wilt has become serious in two localities and is present in others. Drop (*Sclerotinia* spp.), mosaic, and yellows have been found in California. Fortunately for lettuce growers, brown blight and mildew are now under control through the utilization of resistant strains; and some progress has been made with tipburn. Strains that resist tipburn are not liable to become slimy; hence slime control largely depends upon success in breeding tipburn-resistant strains.

Brown Blight.—Lettuce brown blight is known to occur only in California and Arizona. At present it is more prevalent in Imperial Valley than in the Salinas–Watsonville or the Santa Maria sections, but it is likely to become epidemic in the two latter districts in time. Although the cause is still unknown, the inducing agent has been found able to persist in infested soil for long periods, even though nonsusceptible crops are grown. Occasionally the first lettuce crop on "new" land is slightly attacked, the disease gradually becoming more severe with succeeding lettuce crops. The disease has been thought to develop more rapidly in fine, silty, water-deposited soil types than in loamy soils. In some fields of the silt type in Imperial Valley, brown blight has made it impossible to grow more than one or two lettuce crops, whereas in the Salinas–Watsonville district, more profitable crops have been produced on loamy soils.

The disease may manifest itself at any time after the seedlings have developed five leaves, usually after thinning. Plants attacked when small assume a somewhat mottled, sickly, yellow color, become rosetted, and never head. If attacked after heading, the entire plant may become yellowish; and dead, brown irregular streaks and blotches may develop in the leaves.

Although brown blight threatened to become so severe in Imperial Valley that lettuce could no longer be profitably grown, the disease is now under control through the efforts of Dr. I. C. Jagger of the United States Department of Agriculture. Dr. Jagger, who began his investigations in California in 1922, has now distributed numerous strains resistant to brown blight that succeed on infested soil where other strains of

Fig. 25.—Comparison of brown-blight-resistant and nonresistant lettuce. The two center rows are 100 per cent infected. The outer rows of resistant strains show normal growth. (From Ext. Cir. 60.)

Fig. 26.—Spotted wilt on head lettuce. The brown dead spots and curvature of the leaf are characteristic effects. The smaller leaf shows marginal wilting. (Photograph by Division of Plant Pathology.)

New York are a total loss (fig. 25). The adaptability and degree of resistance of these strains are discussed elsewhere in this circular.

Spotted Wilt.—The spotted-wilt virus produces in head lettuce a very destructive disease characterized by brown dead spots, marginal wilting, and curvature of the leaves (fig. 26). One side of a plant is usually af-

fected more than the other. The brown dead spots and streaks are especially conspicuous in the basal portion of the midvein. The leaves of intermediate age are first to show symptoms, but soon the dead spots occur on all the younger leaves, including those in the heart. Young plants flatten out and die (fig. 27) a week or two after symptoms first

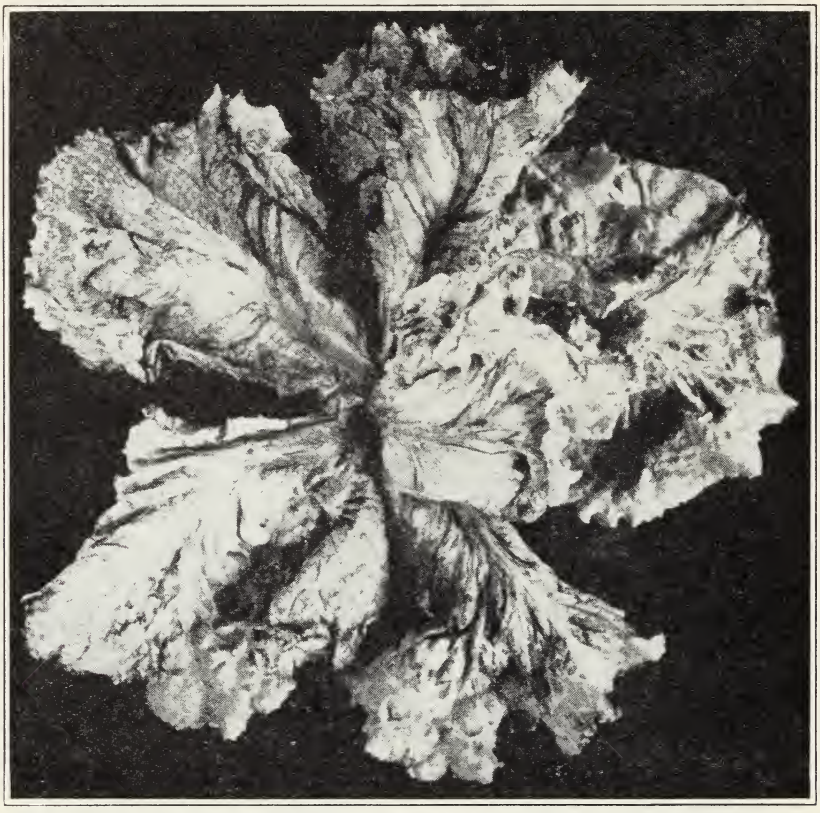

Fig. 27.—A young lettuce plant affected with spotted wilt, showing wilting. (Photograph by Division of Plant Pathology.)

appear. Older plants live longer and are often characterized by a slimy soft rot of the internal leaves. Plants infected late may show no external symptoms; but the internal leaves are affected, and the freshly cut surface of the stem usually shows some brown discoloration at one side.

This disease is extremely serious in a few localities in the fall crop and occurs to a limited extent in other localities. It is at its worst near San Pablo and has been very serious near Gonzales.

The virus that causes spotted wilt is carried by thrips. It occurs also in other crops such as tomatoes, peppers, broad beans, chicory, spinach,

and celery and in numerous ornamentals such as nasturtium, aster, cineraria, calla lily, tuberous begonia, gloxinia, calceolaria, delphinium, dahlia, petunia, zinnia, and sweet pea. It also occurs in nettle, Jimson weed, mallow, and chickweed. Infected plants of any species are potential sources of infection for head lettuce. The disease seems to be worse in lettuce fields adjacent to other crops or to alfalfa.

Fig. 28.—Downy mildew on lettuce leaf. (Photograph by Division of Plant Pathology.)

The disease is usually not prevalent in the early spring crop, probably because the winter rains greatly reduce the thrips population. No control is known. Spraying to kill thrips has not been effective. Numerous varieties of lettuce, including Dr. Jagger's brown-blight-resistant strains, have been tested, but all proved susceptible, as was also wild lettuce.

Brown blight and spotted wilt are similar in that dead spots in the leaves and stunting are symptoms. Plants infected with spotted wilt while young show a curling of the petioles, a curvature of the leaves, and a wilting of the most severely affected leaves, followed rather promptly

by collapse of the entire plant. In contrast, young plants infected with brown blight show only the dead spots in the leaves and the yellow and stunted condition. These diseases are particularly difficult to distinguish when the plants are infected late in life, the dead spots in the leaves of the mature heads being the only conspicuous symptom of each disease.

Downy Mildew.—In the coastal sections downy mildew (*Bremia lactucae*) is usually present every season; in Imperial Valley, only occasionally when there is an unusual amount of rain and dew. The disease also affects endive, chicory, and certain weeds. Certain favoring environmental conditions such as relatively low air temperature and periods of cloudy or rainy weather or heavy dews determine the likelihood of there being injury from this disease. Evidence of its presence is found on either the leaves or seedstalk, and it may occur in any stage of plant growth. On the outer leaves, yellowish or light-green areas develop on the upper surface; the corresponding lower surface is usually covered by a dense, white, fluffy growth of the fungus (fig. 28) which produces the spores capable of infecting other leaves. Infected spots may enlarge or several grow together until much of the leaf may be killed. Under California conditions infected plants seldom die prematurely, but continue to grow more or less salable heads. Irregular white blotches may appear on infected seed stalks. When infected heads are shipped under refrigeration to distant markets, decay may follow mildew injury.

The causal organism remains in the soil for a short time but will not withstand the freezing and thawing of winter in the north. Wild lettuce serves as a host in the "off season," enabling the organism to live over until lettuce is again planted. How long the organism can persist in the soil in either the Imperial Valley or the coastal districts is not definitely known.

Preventive measures include destruction of wild lettuce and other weed hosts and prompt removal or destruction of infected plants as soon as the cutting season is over. Dr. Jagger has developed two resistant strains, Imperial D and F, through hybridization and selection. In 1922 he crossed New York, a susceptible variety, with a resistant French variety of romaine. These hybrids were then crossed with Imperial No. 2 and No. 3 in 1925; and continued selection resulted in the isolation of strains D and F, which are partially resistant to mildew and fully resistant to brown blight. These strains are further discussed elsewhere in this circular.

Tipburn.—Tipburn is a nonparasitic disease generally prevalent when warm, bright days follow periods of foggy or cloudy weather. It is somewhat more severe in poorly drained areas. It is characterized by dark-

brown discoloration near the margin of the leaves (fig. 29). The development of these small dead spots seems to prevent the passage of water to edges of the leaf; and that portion outside the spots becomes wilted and yellow and soon dies, leaving a dead, brown strip around the edge of

Fig. 29.—Tipburn on head lettuce. (Photograph by Division of Plant Pathology.)

the leaf. New York No. 515 is somewhat resistant, but not immune, to tipburn.

Slime.—Lettuce heads subjected to tipburn often develop a slimy soft rot or gray mold in the field or during transit and storage (fig. 30). This condition is caused by *Botrytis* and a number of different bacteria. Heads subjected to frost injury or excessive irrigation often develop slime. Infection usually starts on a protected, injured spot, whence the causal

organisms may spread by means of water, wind, or insects to other plants. Sometimes the outer leaves tend to hide infected areas within the head. If injured leaves at the base of the plant are attacked, *Botrytis* often enters the stem and causes a rot at the soil surface; and the plant wilts.

Fig. 30.—Slime on head lettuce. (Photograph by Division of Plant Pathology.)

Slime develops most rapidly during warm, damp periods, particularly on warm nights; its development is checked by cold, dry weather. In the field, control usually resolves itself into prevention of tipburn. Strains resistant to tipburn are likewise less subject to slime. Where slime is a serious factor, plantings should be regulated so that the crop will mature

in cool weather. The use of high, well-drained beds aids in preventing slime. Harvested heads showing any indication of slime should not be packed for long-distance shipment, for slime is apt to spread during transit.

Fig. 31.—Head lettuce affected with big-vein. (Photograph by Division of Plant Pathology.)

Yellows.—The nature and effects of lettuce yellows indicate that it is potentially serious, although it has not caused appreciable loss in California to date. The disease is induced by a virus spread from diseased to healthy plants, principally by the six-spotted leafhopper, *Cicadula divisa,* an insect extensively distributed in California. Several other species of leafhopper are also capable of transmitting yellows. The leaves of infected plants become yellowed and elongated. They often turn outward instead of inward and fail to head. Diseased plants had best be removed from the field and destroyed.

Big-veined Lettuce.—This disease has been observed in the Imperial Valley for a number of years, and occasional specimens have been seen in the Salinas–Watsonville district. As the name indicates, the veins become

large and coarse (fig. 31). Although the lettuce usually heads, it is smaller than normal. Apparently this is a soil-borne disease, for it persists year after year in the same ground. The acreage affected is small, as yet, but is steadily increasing. The present strains of Imperial are susceptible; but selections are now being made by Dr. Jagger, for resistance.

Other Diseases.—Lettuce drop (*Sclerotinia minor* and *S. libertiana*), mosaic, and mottle-leaf, though known to occur in California, do not yet rank as serious diseases.

SHOOTING TO SEED PREMATURELY

Some loss is always caused by the plants' going to seed prematurely. This trouble usually results from unfavorable soil, moisture, and climate. It is difficult to determine in all cases just what contributing factor or factors have brought about this condition. The best lettuce seed available should be purchased; but, above all, growers should not attempt to grow lettuce under high-temperature conditions, on steep slopes, or on light sandy or gravelly soils not retentive of moisture.

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